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This report describes the accomplishments in research during the grant. It lists the technical reports produced, followed by a list of published papers. The last section provides a summary of the research findings.

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Final Report

ARO Proposal Number	P–23699–MA
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Title of Proposal	Problems in Probability, Statistics and Reliability
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Name of Institution	The Florida State University
Author of Report	Jayaram Sethuraman

ACCOMPLISHMENTS DURING THE GRANT

1 Introduction

In this chapter, we briefly describe the accomplishments in research during the grant. We give a list of the technical reports produced, followed by a list of published papers. In the last section we give a brief summary of the research findings. Most of this research work was also reported at professional meetings.

2 Publications and Technical Reports under the Grant

2.1 List of Technical Reports Prepared under the Grant.

Technical Report No. 85

A Reversal Argument for Storage Models Defined on a Semi-Markov Process, February 1986.

Technical Report No. 86

The Asymptotic Theory for Sieve Estimators in Semi-martingale Regression Models, by I. W. McKeague, March 1986.

Technical Report No. 87

A Two Compartment Storage Model with an Underlying Semi-Markov Process, April 1986.

Technical Report No. 88

Optimal Replacement Age in a Imperfect Inspection Model by D. Herge, F. Proschan and J. Sethuraman, June 1986.

Technical Report No. 89

The Large Deviation Principle for the Sample Average Process and Functional Erdös-Rényi Laws, by J. D. Lynch and J. Sethuraman, June 1986.

Technical Report No. 90

The Renewal Equation for Markov Renewal Processes with Applications to Storage Models, by E. S. Tollar, June 1986.

Technical Report No. 91

On the Elementary Theorems of Decisions Theory, by N. R. Chaganty, June 1986.

Technical Report No. 92

Large Deviation Local Limit Theorems for Random Vectors, by N. R. Chaganty and J. Sethuraman, July 1986.

Technical Report No. 93

Optimal Assembly of Systems, using Schur Functions and Majorization, by E. El-Neweihi, F. Proschan, and J. Sethuraman, July 1986.

Technical Report No. 94

Strong Large Deviation and Local Limit Theorems, by N. R. Chaganty and J. Sethuraman, July 1986.

Technical Report No. 95

Nonparametric Inference in Additive Risk Models for Counting Processes, by I. W. McKeague, August 1986.

Technical Report No. 96

Survival Analysis using Additive Risk Models, by Ian W. McKeague and Fred W. Huffer, April 1987.

Technical Report No. 97

A Counting Process Approach to the Regression Analysis of Grouped Survival Data, by I. W. McKeague, September 1987.

Technical Report No. 98

Inference in Nonlinear Semimartingale Regression Model, by I. W. McKeague and K. J. Utikal, November 1987.

Technical Report No. 99

Stochastic Comparisons of Order Statistics, with Applications in Reliability, by J. S. Kim, F. Proschan and J. Sethuraman, November 1987.

Technical Report No. 100

Asymptotic Theory for Weighted Least Squares Estimators in Aalen's Additive Risk Model, by I. W. McKeague, November 1987.

Technical Report No. 101

Bias reduction when there is no unbiased estimate, by H. Doss and J. Sethuraman, January 1988.

Technical Report No. 102

Stochastic Calculus and Survival Analysis, by I. W. McKeague and K. J. Utikal, June 1988.

Technical Report No. 103

Identifying Nonlinear Covariate Effects in Semimartingale Regression Models, by I. W. McKeague and K. J. Utikal, June 1988.

Technical Report No. 104

Families of Distributions Characterized by Two Moments, by M. C. Bhattacharjee and J. Sethuraman, September 1988

Technical Report No. 105

Goodness-of-fit Tests for Additive Hazards and Proportional Hazards Models, by I. W. McKeague and K. J. Utikal, October 1988.

Technical Report No. 106

Strong Large Deviation and Local Limit Theorems, by N. R. Chaganty and J. Sethuraman, August 1989.

Technical Report No. 107

Nonparametric Estimation of Trends in Linear Stochastic Systems, by I. W. McKeague and K. J. Utikal, October 1989.

Technical Report No. 108

A Diffusion Process Defined on a Fractal Space, by W. B. Krebs, July 1989.

Technical Report No. 109

Two Partial Orderings for Distributions, Derived from Schur Functions, by K. Jogdeo and J. Sethuraman, September 1989.

Technical Report No. 110

Some Nonparametric Methods for Imperfect Repair Models, by M. Hollander, B. Presnell and J. Sethuraman, November 1989.

2.2 List of Publications under the Grant.

Estimation for a Semimartingale Regression Model using the Methods of Sieves, by I.W. McKeague (1986). *Annals of Statistics* **14** 579–589.

The Coding Capacity of Mismatched Gaussian Channels, by I. W. McKeague and C. R. Baker (1986). *IEEE Transactions on Information Theory* **32** 431–436.

Optimum Allocations of Components in Parallel-Series and Series-Parallel Systems, by E. El-Neweihi, F. Proschan and J. Sethuraman (1986). *Journal of Applied Probability* **23** 770–777.

Multidimensional Large Deviation Local Limit Theorems, by N. R. Chaganty and J. Sethuraman (1986). *Journal of Multivariate Analysis* **20** 190–204.

Schur-Ostrowski Theorems for Functionals in $L_1(0,1)$, by W. Chan, F. Proschan and J. Sethuraman (1987). *SIAM Journal and Mathematical Analysis* **18** 566–578.

Large Deviations for Processes with Stationary Independent Increments, by J. D. Lynch and J. Sethuraman (1987). *Annals of Probability* **15** 610–627.

Limit Theorems in the Area of Large Deviations for Some Dependent Random Variables, by N. R. Chaganty and J. Sethuraman (1987). *Annals of Probability* **15** 628–645.

Optimal Assembly of Systems using Schur Functions and Majorization, by E. El-Neweihi, F. Proschan and J. Sethuraman (1987). *Naval Research Logistics Quarterly* **34** 703–712.

A Survey of the Method of Sieves, by I. W. McKeague (1987). Under the entry SIEVES, *Encyclopedia of Statistical Sciences* **8** 458–461.

Stochastic Comparisons of Order Statistics, with Applications in Reliability, by Jee Soo Kim, Frank Proschan and Jayaram Sethuraman (1988). *Communications in Statistics* **17** 2151–2172.

A Characterization of the Gamma Distribution from a Random Difference Equation, by Eric Tollar (1988). *Journal of Applied Probability* **25** 142–149.

On the Limit Behavior of a Multicompartment Storage Model with an Underlying Markov Chain by Eric S. Tollar (1988). *Advances in Applied Probability* **20** 208–227.

Large Deviation Local Limit Theorems for Random Vectors, by N. R. Chaganty and J. Sethuraman. In *Proceedings of the International Conference on Advances in Multivariate Statistical Analysis*, ed. S. S. Dasgupta and J. K. Ghosh (1988) 97–110.

A Counting Process Approach to the Regression Analysis of Grouped Survival Data, by I. W. McKeague. *Stochastic Processes and their Applications* (1988) **28** 221–239.

Asymptotic Theory for Weighted Least Squares Estimators in Aalen's Additive Risk Model, by I. W. McKeague. *Contemporary Mathematics* (1988) **80** 139–152.

A Note on the Elementary Theorems of Decision Theory, by N. R. Chaganty. *Statistics and Decisions* (1989) **7** 185–192.

The price of bias reduction when there is no unbiased estimate *Annals of Statistics* (1989) **17 (1)** 440-442 (with Hani Doss).

2.3 List of Papers Accepted for Publication.

Convex-Ordering Among Functions, With Applictions to Reliability and Mathematical Statistics, by W. Chan, F. Proschan and J. Sethuraman. To appear in *Proceedings of the Dependency Conference held at Pittsburgh, PA in August 1987.*

Families of Distributions Characterized by Two Moments, by M.B. Bhattacharjee and J. Sethuraman. To appear in *Journal of Applied Probability* .

Stochastic Calculus as a Tool in Survival Analysis: a Review, by I. W. McKeague and K. Utikal. To appear in a special issue of *Applied Mathematics and Computation* devoted to "Theory and Applications of Stochastic Differential Equations (Ordinary and Partial)," ed. T.E. Unny (1989).

Inference for a Nonlinear Counting Process Regression Model, by I. W. McKeague and K. Utikal. To appear in *Annals of Statistics* (1989).

Nonparametric Estimation of Trends in Linear Stochastic Systems. To appear in *Statistical Inference from Stochastic Processes* **1** (1990) (with T. Tofoni).

Identifying Nonlinear Covariate Effects in Semimartingale Regression Models, by I. W. McKeague and K. Utikal, to appear in *Probability Theory and Related Fields* (1990).

Weighted Least Squares Estimation for Aalen's Additive Risk Model, by I. W. McKeague and F. Huffer, to appear in *Journal of the American Statistical Association* (1991).

3 Nontechnical summary of research carried out under the grant

3.1 Reliability Theory.

Optimal Allocation and Repair Models:

Technical Report No. 88 obtains the optimum replacement age for a device which is maintained by an age replacement policy and where errors may be made about the status of the device during inspection.

A general assembly of n systems from k types of components is considered in Technical Report No. 93. The techniques of majorization and Schur-Functions are utilized to pinpoint the optimal assembly under several criteria. Earlier results of Derman, Lieberman and Ross and El-Neweihi, Proschan and Sethuraman are generalized.

Often times data are available not on failure times of items that are replaced by new items at each failure, but on failure times of items that are constantly repaired at each failure till replaced by a new items according to some policy of maintenance. In Technical Report No. 110 we study methods of estimating and testing failure life distributions from such data.

Stochastic Comparisons in Reliability:

In Technical Report No. 90 we review recent developments on stochastic compar-

ison of order statistics are reviewed under the following headings: (1) Stochastic comparisons of linear combinations of order statistics from distributions F and G where $G^{-1}F$ is convex or star-shaped, (2) Stochastic comparisons of individual order statistics and vectors of order statistics from underlying heterogeneous distributions by the use of majorization and Schur function theory, and (3) Stochastic comparison of random processes. Applications to reliability problems are presented illustrating the use and value of the theoretical results described.

In Technical Report No. 104, we consider several classical notions of partial orderings among life distributions. We show that if a distribution G dominates another distribution F in one of these partial orderings, and if two moments of G agree with those of F, including the moment that describes the partial ordering, then $G = F$. This leads to a characterization of the exponential distribution among HNBUE and HWUE life distribution classes. These results extend those in a paper of Basu and Bhattacharjee and at the same time rectify an error in their paper.

In Technical Report No. 109, we describe two basic partial orderings for distributions that are derived from Schur functions. This is an expository paper on our earlier work on Stochastic Majorization and DT functions and their uses in Statistics. An earlier result on DT functions is generalized in this paper.

3.2 Statistics.

Decision Theory and Inference:

Technical Report No. 101 studies the pitfalls of bias reduction methods when it is known that an unbiased estimate does not exist. When an unbiased estimate does not exist and when there is a sequence of estimators whose biases go to zero, it is shown under mild conditions that the variances of these estimates must necessarily go to infinity.

The elementary theorems of decision theory, namely the Minimax theorem, the Complete class theorem, and theorems on the structure of admissible rules when nature has a finite number of states, are proved in most texts under the assumptions that the risk set is closed from below and bounded from below. The condition that the risk set is bounded from below is sufficient for the existence of the lower boundary points: however, that it is not necessary can be seen from simple examples. Technical Report No. 91 extends the elementary theorems of decision theory to include the case in which the risk set is not bounded from below and the set of lower boundary points is nonempty.

Inference from Stochastic Processes:

In Technical Report No. 86 the asymptotic properties of the sieve estimators in a semimartingale regression model are investigated. Functional central limit theorems for integrated hazard-type functions arising in the model are obtained. These results are used to give confidence intervals and bands for nonparametric point processes and diffusion process regression models. Techniques from operator theory, approximation theory and martingale inequalities are used to obtain these results.

In Technical Report No. 95, we study nonparametric estimators for the hazard functions in an additive risk model for counting processes. Functional central limit theorems for the integrated estimators are established and used to find the asymptotic null distribution of a maximal deviation statistics for Kolmogorov-Smirnov type testing. In addition, we provide confidence bands for the integrated hazard functions and showed that certain smoothed versions of the hazard function estimators are uniformly consistent.

The counting process approach to survival analysis is used to obtain the asymptotic properties of least squares estimators for additive risk models in Technical Report No. 96. The methods are developed for both continuous and grouped survival data. A simulation study is carried out and an application to the analysis of cancer mortality among Japanese atomic bomb survivors is given.

The theory of counting processes is used to give an approach to regression analysis of grouped (and possibly censored) survival data in Technical Report No. 97. The asymptotic properties of grouped data versions of weighted least squares estimators introduced in an earlier Technical Report (No. 96) are derived.

In Technical Report No. 98 a nonlinear extension of Aalen's multiplicative intensity model is introduced and studied. Methods of inference for conditional hazard functions are developed using martingale techniques. Previously, such methods were only available in the restrictive case of time-independent covariates.

In Technical Report No. 100 inference for Aalen's additive risk model based on continuous data is studied. Weak convergence results for weighted least squares estimators of the hazard functions and the cumulative hazard functions are obtained. These results are the continuous data analogues of the grouped data results given in Technical Report No. 97.

In Technical Report No. 102 we give a brief survey of the uses of stochastic calculus in survival analysis. The role played by martingale central limit theory in deriving asymptotic distributions of estimators and test statistics is described. The Nelson-Aalen estimator, Kaplan-Meier estimator, Cox's proportional hazards model, Aalen's additive risk model and a goodness-of-fit test for Cox's model are discussed. Sketches of the proofs of the main results are included.

In Technical Report No. 103 we continue our study of the nonlinear extension of Aalen's multiplicative intensity model introduced in Technical Report No. 98. We study inference for the conditional hazard function $\alpha(t,z) = \alpha(t|z)$ of a survival time given a covariate z by using an estimator for the doubly integrated conditional hazard function $\mathcal{A}(t,z) = \int_0^z \int_0^t \alpha(s,x)\, ds\, dx$ and deriving a functional central limit theorem for the estimator. The asymptotic distribution turns out to be given by a Gaussian random field that admits a representation as a stochastic integral with respect to a multiparameter Wiener process. This result is used to develop a test for independence of X from the covariate Z, a test for time-homogeneity of α, and a goodness-of-fit test for the proportional hazards model $\alpha(t,z) = \alpha_1(t)\alpha_2(z)$.

Additive hazards and proportional hazards regression models used in the analysis of censored survival data can give substantially different results. For instance, in connection with a study of cancer mortality among Japanese atomic bomb survivors, it has been noted that the two models give substantially different estimates of the age-specific probability that an individual will develop radiation induced cancer. In Technical Report No. 105 we develop goodness-of-fit tests for Cox's proportional hazards model and Aalen's additive risk model, in which each model is compared on an equal footing with the best fitting fully nonparametric model. The goodness-of-fit statistics are based on differences between estimates of the doubly cumulative hazard function (integrated over both time and covariate) under each model, with a fully nonparametric estimate. Comparison of the results of the tests makes it possible to decide whether Cox's proportional hazards or Aalen's additive risk model gives a better fit to the data.

In Technical Report No. 107 we introduced several methods for estimating unknown additive trends in the state and measurement processes of a Kalman–Bucy linear system. We obtain asymptotic results describing the performance of the estimators under i.i.d. and periodic observation schemes. Some potential applications of our results include the analysis of circadian rhythm data in biology, and the study of cyclic systems in control engineering.

Stochastic Models:

The usual Technique for determining the asymptotic behavior of storage models defined on a semi-Markov process is to apply the renewal equations. While this technique has met with limited success, the limit distribution of the discrete time imbedded process can often be determined by exploiting the properties of the dual process. If this is the case, a technique is presented in Technical Report No. 85 which, under certain reasonable regularity conditions of the storage model shows, that the limiting distribution of the entire process can be obtained via the dual process. It is shown that this technique will (a) yield results not obtainable by the renewal arguments, and (b) improve on results which can be obtained by the renewal argument.

In Technical Report No. 87 a storage model with an underlying semi-Markov process is proposed to model the behavior of a two compartment storage model with one way flow. It is shown that based on first moment assumptions of the input/transfer/output process, the divergence or convergence of each compartment is determined. For the eight separate cases in which at least one compartment does not converge, the bivariate asymptotic behavior of the compartments is determined, when appropriately normalized.

For Markov renewal processes in which the sojourn times are controlled by an imbedded, denumerable state Markov chain, it is shown in Technical Report No. 90 that there exists a random time at which the Markov renewal process regenerates. The basic renewal theorem is then applied to determine the limiting behavior of the Markov renewal process. These results are applied to a particular two compartment storage model to determine the limiting behavior of the amounts in storage.

3.3 Probability

Large Deviations:

In Technical Report No. 89 the large deviations principle is established for the sample average process. This is used to obtain function space counterparts to Erdös-Rényi type laws.

In Technical Report No. 92, we present a survey of large deviation local limit theorems for random vectors. We then establish a more extensive large deviation local limit theorem that requires somewhat weaker conditions even in the special cases proved earlier.

Most large deviation results give asymptotic expressions only of the logarithm of large deviation probabilities. In Technical Report No. 94, we obtain asymptotic expressions to actual large deviation probabilities of arbitrary random variables. These results depend on local limit theorems for arbitrary random variables which are also proved in this paper.

In Technical Report No. 108, a simple randomwalk is defined on a skeletal lattice of the Vicsek snowflake, which is shown to converge weakly to a limiting process on the snowflake, after scaling in time and space. This limiting process has continuous sample paths and the strong Markov property, and is the unique difusion limit of the random walk on the snowflake in a natural sense. This diffusion has a scaling property reminiscent of the Brownian Motion and possesses a transition density with respect to the Hausdorff measure on the snowflake.

4 Professional activities during the period covered by the grant

4.1 J. Sethuraman:

Attended and gave an invited talk at the conference on Reliability and Quality Control at the University of Missouri, Columbia MO, June 7–10, 1986.

Attended the NSF-CBMS Conference on Stochastic Processes in the Neurosciences at North Carolina State University, Raleigh, NC, June 23–27,1986.

Attended and gave an invited talk at the Western Regional Meeting of the IMS at Washington University, Seattle, WA, July 28–31, 1986.

Attended the Mathematics and Statistics Chairmen's meet at Washington, DC, October 9–11, 1986.

Attended and gave an invited talk at the Army Design of Experiments Workshop at Monterey, CA, October 28–November 2, 1986.

Participated in a meeting of the Committee on Applied and Theoretical Statistics (CATS) at Washington, DC, February 5–7, 1987.

Gave a seminar at the Department of Statistics, University of Iowa, Iowa City, IA, April 22–24, 1987.

Gave a seminar at the Department of Mathematics, University of North Carolina, Charlotte NC, April 28–29, 1987.

Presented a paper at the Eastern Regional Meetings of the IMS at Blacksburg, VA, May 26–29, 1987.

Presented a paper at the Workshop for Computational Statistics at George Mason University, Fairfax, VA, June 2–4, 1987.

Gave a Seminar at the Department of Biostatistics, University of Washington, Seattle, WA, June 11, 1987.

Gave an invited talk at the Symposium on Dependence in Statistics and Probability, at Pittsburgh, PA in August 1987.

Participated in the Joint Annual Meeting of the ASA/IMS and the Committee on Applied and Theoretical Statistics at San Francisco, CA in August 1987.

Gave a talk at the 46th Session of the International Statistical Institute in Tokyo, Japan in September 1987.

Attended the Meeting of Mathematics Departments' Chairs in Washington, DC in October 1987.

Gave seminars at the Indian Statistical Institute, Bangalore, Indian Statistical Institute, Calcutta and Madras University, Madras, India in November 1987.

Participated in the Annual Meeting of the American Mathematical Society at Atlanta, GA, January 6–9, 1988.

Presented a talk and chaired a session at the Meeting of the Florida Chapter of the American Statistical Association, Tallahassee, February 12–13, 1988.

Gave a talk at the Department of Statistics, University of Florida, Gainesville, FL on April 14, 1988.

Participated in a meeting of the Committee on Applied and Theoretical Statistics (CATS) at Washington, DC, February 5–6, 1988.

Presented a series of invited talks at King Saud University, Riyadh, Saudi Arabia from May 22 to June 10, 1988.

Attended the NSF-CBMS conference on Empirical Processes: Theory and Applications by David Pollard at the Department of Statistics, University of Iowa, Iowa City, IA, June 20–24, 1988.

Visited the Department of Mathematics at the University of Wisconsin, Madison, WI, a member of a site visit team for NSF Science and Technological Centers, July 19–21, 1988.

Presented an invited paper and chaired a session at the Annual meeting of the Institute of Mathematical Statistics at Fort Collins, CO, August 13–19, 1988.

Elected as a member of the Council of the Institute of Mathematical Statistics, August 1988.

Participated in the Annual Meeting of the American Statistical Association and the Committee on Applications and Theory of Statistics at New Orleans, LA, August 22–25, 1988.

Attended the meeting of the Committee of Statistics of the Southern Regional Educational Board at Jacksonville, FL, October 4–7, 1988.

Attended the meeting of Mathematics Chairs run by the Board on Mathematical Sciences at Washington, DC, October 14–16, 1988.

Gave a seminar talk at the Department of Mathematics, University of Maryland, Baltimore County, Catonsville, MD, November 4–6, 1988.

Gave an invited talk and participated in the Indo-US Workshop on Bayesian Analysis at Bangalore, India, December 19–23, 1988.

Participated in the meeting of the Committee on Applied and Theoretical Statistic (CATS) in Washington, DC, February 3–4, 1989.

Gave a colloquium at Columbia University, NY, April 29-May 2, 1989.

Attended the Sigma Xi conference to honor Professor John Tukey at the Georgia Institute of Technology, Atlanta, GA, May 12,1989.

Gave a seminar at the University of South Florida, Tampa, FL, May 22, 1989

Participated in the NSF Summer Meetings on the Mathematics of Random Media at the Virginia Polytechnic Institute, Blacksburg, VA, June 3–9, 1989.

Participated at the Western Regional Meetings of the Institute of Mathematical Statistics at the University of California, Davis, CA, June 23–28, 1989.

Presented a paper at the joint annual meeting of the IMS and ASA in Washington, DC, August 1989.

Represented the Statistics Department at the Southern Regional Council on Statistics at Columbia, SC, September 29–30, 1989.

Presented a paper at the Army Design of Experiments Workshop at Monterey, CA, October 18–20, 1989.

Organized and chaired the Statistics sessions at the Annual Mathematics Chairs Colloquium in Washington, DC, October 27–28, 1989.

4.2 I. W. McKeague:

Attended and gave a talk at the NSF-CBMS Conference on Stochastic Processes in the Neurosciences at North Carolina State University, Raleigh, NC, June 23–27, 1986.

Visited the Matematiska Institutionen, Abo Akademi, Turku, Finland, to act as the opponent at the public examination of the Ph.D. thesis of Timo Koski, October 20–24, 1986.

Gave a seminar at the Applied Mathematics and Statistics Department, University of Oulu, Oulu, Finland, October 27, 1986.

Gave seminars at the Department of Mathematics and the Department of Statistics, University of Helsinki, Helsinki, Finland, October 29–30, 1986.

Gave a seminar at the Department of Statistics, University of North Carolina, Chapel Hill, NC, February 9–10, 1987.

Gave a seminar at the Department of Statistics, Florida State University, Tallahassee, FL, February 24, 1987.

Gave a seminar at the Department of Statistics, University of Kentucky, Lexington, KY, April 16–17, 1987.

Gave an invited paper at the Eastern Regional Meetings of the IMS at Blacksburg, VA, May 26–29, 1987.

Gave an invited talk at the AMS/IMS/SIAM Joint Summer Research Conference on Inference form Stochastic Processes, Cornell University, Ithaca, August 1987.

Gave an invited talk at the Satellite Meeting on Mathematical Sciences and Probability for the 46th Session of the ISI, Kyoto, Japan, September 1987.

Session Chairman, Meeting of the Florida Chapter of the American Statistical Association, Tallahassee, February 12–13, 1988.

Presented an invited talk at the University of Cambridge, England, Statistical Laboratory, Department of Pure Mathematics and Mathematical Statistic, December 9, 1988.

Presented an invited talk at the Meeting on Martingale Methods in Statistics, Mathematisches Forschungsinstitut Oberwolfach, West Germany, December 11–17, 1988.

Presented two invited talks at the University of Padua, Italy, Department of Statistics, December 19–21, 1988.

4.3 N.R. Chaganty:

Gave a talk at a meeting of the Virginia Academy of Science at Norfolk, VA, May 21–24, 1987.

Gave a seminar at the Reliability Seminar Series, Department of Statistics, Florida State University, Tallahassee, FL, June 24, 1987.

Gave a talk at the 46th Session of the International Statistical Institute in Tokyo, Japan in September 1987.

Gave a talk at the University of Singapore, Singapore in September 1987.

4.4 W. B. Krebs:

Attended the International Symposium on Applied Probability, Sheffield, U.K., August 14–18, 1989.

5 Ph. D. Degrees Awarded

Dr. Klaus Utikal: Inference for a Nonlinear Semimartingale Regression Model, 1987.

Dr. Brett Presnell: Nonparametric Methods for Imperfect Models, 1989 (dissertation directed jointly with Myles Hollander).

Dr. Thomas R. Young: A New Family of Survival Functions Derived from a General Cumulative Damage Threshold Crossing Model for Evolving Structural Systems of Improving Components with Biomedical and Accelerated Life Testing Applications , 1990 (dissertation directed by Jayaram Sethuraman).

6 List of participating personnel

Jayaram Sethuraman, Florida State University

Ian W. McKeague, Florida State University

W. Barney Krebs, Florida State University

Narasinga R. Chaganty, Old Dominion University

Kumar Jogdev, University of Illinois, Urbana

Emad El-Neweihi, University of Illinois, Chicago